

F_o by proper design of its surfaces S1 and S2. Now since F_o is the required power for the odd Fresnel zones, in this situation, we only need to implant ions to form the even zones, so as to modify the carrier lens power from F_o to F_e for these even zones. This leads to a simpler construction than that of FIG. 5. Naturally we are not limited to bifocals, but can also consider trifocals, quadrifocals, etc. For example, in FIG. 7 we see an ion implanted phase shift "trifocal" zone plate. One primary focal power F_o , is confined to the odd zones labeled O, while the other two primary powers F_{e1} and F_{e2} , are distributed alternately throughout the even zones which are labeled E1 and E2. Again, the zones must be formed by bounding radii r_n , where $r_n = \sqrt{nd\lambda}$. In this case it is most advantageous to set the powers F_o , F_{e1} , and F_{e2} such that we have $F_{e2} - F_o = F_o - F_{e1}$. Then we can set $d = F_{e2} - F_o = F_o - F_{e1}$. This creates double focii at all three focal powers F_o , F_{e1} , and F_{e2} .

Another embodiment of the present invention, which utilizes ion implantation, is shown in FIG. 8, where the Fresnel zones are formed by ions implanted alternately into the opposite surfaces of the carrier lens, so as to create the odd zones beneath the anterior lens surface S1, and the even zones beneath the posterior lens surface S2. And an interesting variant of this idea combines features of the embodiments of FIGS. 6 and 8, to yield the embodiment of FIG. 9. In this embodiment, we let the carrier lens have the odd zone power F_o , as in the embodiment FIG. 6, but make use of both of the lens' surfaces, as in the embodiment of FIG. 8, to form the even zones by ion implantation. This design is useful in those cases where the depth of ion implantation would be a limiting factor in altering the power of the Fresnel zones, by allowing for double the power change achievable by using one surface alone. It is clear that many other variations can be achieved by combining different features of the embodiments of FIGS. 5, 6, 7, and 8, to produce a multitude of different multifocal zone plate configurations.

Two additional embodiments of the present invention are mirror body constructions. FIG. 10 shows a phase shift multifocal Fresnel zone plate mirror with zone plate spacings. The mirror body is made with a reflecting surface R, and has facets alternating in power between the odd and even zones. Features of the design of the embodiment shown in FIG. 4, can be used to modify the phase shift multifocal Fresnel zone mirror of FIG. 10, so as to eliminate all of the non-reflective ledges L on the surface. In FIG. 11 we see a compound lens-mirror system. The mirror M has a reflective surface R, and onto this surface an optically refractive material is deposited to form a lens ML. The Fresnel zones O and E, are then formed in the lens by ion implantation. Again all of the design features illustrated in FIGS. 3-8 are directly applicable, and will produce different and use-

ful embodiments of a phase shift multifocal zone plate lens-mirror.

It should be understood, of course, that the foregoing disclosure relates only to the preferred embodiments of the invention, and that numerous modifications or alterations may be made therein, without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is new and desired to be protected by Letters Patent is:

1. A multiple focal power optical device comprising: body means having a plurality of alternating odd and even, annular, concentric zones, bounded on the outside by radii r_n , with $n=1,3,5,\dots$, for the odd zones and $n=2,4,6,\dots$, for the even zones;

first focal power means within at least some of the odd zones for directing incident parallel light to a first focal point;

second focal power means within at least some of the even zones for directing incident parallel light to a second focal point different from said first focal point;

wherein the radii r_n of said odd and even zones are substantially proportional to the square root of n ; and wherein the absolute value of r_1 is set equal to $\sqrt{\lambda d}$, with λ equal to the wavelength under consideration, and d is substantially equal to the reciprocal of the absolute value of the difference between the first and second focal powers.

2. The invention of claim 1 wherein said body means comprises an optically refracting material.

3. The invention of claim 2 wherein said first and second focal power means comprise a plurality of discreet refracting elements within their respective annular zones.

4. The invention of claim 3 wherein at least some of said optically refracting elements include contaminants imbedded in said body means to achieve the desired focal powers.

5. The invention of claim 4 wherein the discreet refractive elements of the first focal power means occupy every odd zone, and the discreet refractive elements of the second focal power means occupy every even zone.

6. The invention of claim 1 further including a third focal power means within at least some of the annular zones.

7. The invention of claim 1 wherein the body means is designed to act as an ophthalmic bifocal spectacle lens.

8. The invention of claim 1 wherein the body means is designed to act as an ophthalmic bifocal contact lens.

9. The invention of claim 1 wherein the said body means comprises an optically reflecting material.

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